PM3000

USER HANDBOOK

Voltech

PM3000

USER HANDBOOK

PM3000 UNIVERSAL POWER ANALYSER USER MANUAL
VERSION 3.01

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ANALOG OUTPUTS ONLY

In this mode the waveforms on each input are digitized and sent to the analog outputs. The outputs can therefore be conveniently viewed in real time at a safe potential (0 - 5V). The voltage and current ranges can be changed to obtain the best resolution but all other measurement functions cease while this mode is active. For this reason it is not possible to enter this mode while the integrator is running.

Press the 'INTERFACE' key

Use the 'SELECT' key to choose the 'ANALOG' menu. The display will then show 'ANALOG OUTPUTS ONLY' and the waveforms seen by the a-d converters will be output to the analog connector.

ANALOG CONNECTOR 25 WAY 'D' SOCKET	PIN	WAVEFORM
	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	9	CH3 AMPS
	11	CH3 VOLTS
	2-16 EVEN	GROUND

This function can be cancelled by pressing the 'INTERFACE' key again.

AVERAGING

The averaging feature allows for stable and accurate readings with inputs which can be fluctuating.

Results from a number of measurement cycles can be averaged in averaging stores. The length of the averaging stores can be programmed by the user.

There are two sets of averaging stores; the display averaging stores and the background averaging stores.

The display averaging stores serve to average all the results that are displayed on the front panel, and can average up to 64 measurements.

The backgound averaging stores serve to average results that are required to be output to external interfaces, and can average up to 16 measurements.

AVERAGING METHOD

The results to be averaged are placed in an averaging store of user defined length. As a new result is made available the contents of the store are moved down one position. The new result is placed at the top of the store and the oldest result in the store is discarded.

There are two modes of averaging:

i. AUTO

This is the default and will set the maximum averages to 16. The PM3000 will reset the auto averaging if there is a marked change in either the voltage or current inputs. It therefore provides a quick response time while still retaining the benefits of averaging.

ii. N

This allows the user to set the averaging stores to be any length from 1 - 64. Where the number is set to greater than 16, the backgound averaging stores will be set at 16. The PM3000 will not reset this averaging on account of any changes of the input voltage and current.

Pressing any key on the front panel will reset the display averages, but the background averages will not be affected unless the basic mode of operation is changed.

CHART RECORDERS

The PM3000 has eight chart recorder outputs. Each output can also act as an alarm. e.g. CH2 volts over 255V.

The following functions can be programmed as recorder outputs

- Watts
- Fundamental Watts
- Volt-Amps
- Fundamental Volt-Amps
- VArs
- Fundamental VArs
- Volts
- Fundamental Volts
- Amps
- Fundamental Amps
- Power factor
- Fundamental Power factor

These can be either CH1, CH2, CH3, or SUM.

Also
- Neutral Amps
- Neutral Fundamental Amps
- Frequency

These outputs can be ranged to obtain the maximum resolution.

TO SET UP THE CHART RECORDERS

Press the 'INTERFACE' key

Use the 'SELECT' key to choose the 'RECORDERS' menu. Select 'ENABLE'.

The top line of the display will show the chart recorder number (1-8), the channel, the function, and 'Fund' if it is the fundamental.

The bottom line of the display will show the low and high limits if any have been entered. Outputs will be 0-5V with 0V corresponding to the low limit and 5V corresponding to the high limit.

Pressing the 'SELECT' key will move on to the next recorder channel. 'ENTER' will allow new setups for the recorder channel displayed.

Press 'ENTER'

The bottom line will now show 'ENTER CHANNEL AND FUNC'. The channel can be selected by using the five 'CHANNEL SELECT' keys under the display. The function can be selected by pressing the required function button. Pressing 'FUND' will alternatively select and deselect the fundamental.

When the entries are correct on the top line press 'ENTER'.

The display will now prompt for a low limit. The numeric data can be entered with the keys 0-9, the '.' key, and the 'k,M' key. The 'SELECT' key will clear any incorrect entry and also toggle the '+' and '-' signs for functions that have polarity.

For example:
If the display shows + 0. and the user wishes to enter -10000

Press the 'SELECT' key to change the sign.	- 0.
Press '1' and then '0'	- 10.
Press the 'kM' key	- 10.k

Press 'ENTER' and the the display will ask for the high limit.

Once the high limit has been entered the display will show the next recorder channel. Press 'ENTER' to edit 'SELECT' to move on. To exit the menu press 'SELECT' until 'R[9] QUIT' appears on the display and then press 'ENTER'.

The recorder outputs will then be available on the 'analog-alarms' connector on the rear panel. They will be present all the while the instrument is making normal measurements.

TO SET ALARMS

To set alarms simply program the low and high limits to the same value. If the measured value is below the limit the recorder o/p will be 0V, if the measured value is above the limit the recorder o/p will move to +5V.

ANALOG CONNECTOR 25 WAY 'D' SOCKET	PIN	CHART RECORDER
	1	R1
	3	R2
	5	R3
	7	R4
	9	R5
	11	R6
	13	R7
	15	R8
	2-16 even	GROUND

CHANNEL SELECT

The CH1, CH2 and CH3 keys allow the user to select the phase corresponding to the measurements given on the front panel display. The CH2 and CH3 keys are only available if the WIRING setup enables the phase in question.

'SUM' displays the summation (total) value for the multiphase system. Using the display menu, SUM can be used to simultaneously show the measurements of all three channels plus the total.

Only functions which have a meaningful summation value will give results with 'SUM'.

'N' will show the value of the results of the analysis of the neutral currents. Only Arms, Amean, Apk, Acf, Athd and A Harmonics can be displayed.

The neutral is not measured directly but is computed from the instantaneous values of the individual phase currents.

CHANNEL 3 ONLY

This permits channel 3 to be used in a single channel mode independant of the inputs to channels 1 and 2.

For example to measure the input and the output of a single phase frequency converter the input could be wired into channel 1 and the output into channel 3. By selecting single phase two wire wiring the input could be analysed, and then by selecting channel 3 only the output could be measured.

Three possible configurations are:

i. Single phase in (ch1) , single phase out (ch3).

ii. 3 phase in (two wattmeter method)(ch1+2) , 1 phase out (ch3).

iii. Single phase in (ch3), three phase or dual outputs (ch1+2).

Efficiency is calculated by (output power / input power) * 100%.

To select this mode press the 'F' button and select F[4].
Use the 'SELECT' key to enable 'CHANNEL 3 ONLY'.

The channel 3 display LED and the single phase two wire LED will illuminate to show that channel 3 only is being measured.

The inputs to channels one and two will be ignored.

Use the F[4] function to return to normal operation.

Note DATA LOG is not available with 'CHANNEL 3 ONLY' selected.

If the channel 1+2 setup is saved in program store P[1] and the channel 3 setup is saved into P[2], the instrument can then be switched from measuring channels 1+2 to measuring channel 3 with a single touch of a button (see PROGRAM SWITCH).

DATA LOG

The data log function is used to capture transitory events. It is not for long term data logging.

The user has to specify the capture time, the voltage and current ranges (auto ranging is not available in data log), and the trigger.

Once triggered the instrument takes a number of samples on all channels over the chosen capture time. This data is then analysed.

The results from the analysis are not available from the front panel display. Prior to using data log the user has to specify the functions to be printed (printer menu). When the results have been computed they will automatically be sent to the printer.

The captured waveforms are made available on the chart recorder outputs for visual inspection.

TO USE THE DATA LOG FUNCTION

If a printout is required a selection of results to be printed must first be made from the printer menu.

Check that the correct wiring, coupling, shunt etc has been chosen.

Press the 'DATA LOG' key.

The display will prompt for a capture time to be entered. This is the the duration of the sampling after the trigger. Use the 'SELECT' key to pick the most suitable time.

The following table show the capture times available together with the sample rates and number of samples.

DATA LOG -- SAMPLE RATES

WIRING	CAPTURE TIME	SAMPLE RATE	NUMBER OF SAMPLES/CHANNEL
SINGLE PHASE TWO WIRE	30 mSec	5.25 uS	6000 samples
	60 mSec	10.5 uS	6000 samples
	300 mSec	50 uS	6000 samples
	1 Sec	170 uS	6000 samples
	5 Sec	850 uS	6000 samples
SINGLE PHASE THREE WIRE / THREE PHASE THREE WIRE	30 mSec	10.5 uS	3000 samples
	60 mSec	21 uS	3000 samples
	300 mSec	100 uS	3000 samples
	1 Sec	340 uS	3000 samples
	5 Sec	1.7 mS	3000 samples
THREE PHASE FOUR WIRE	30 mSec (*)	21 uS	3000 samples
	60 mSec	21 uS	3000 samples
	300 mSec	100 uS	3000 samples
	1 Sec	340 uS	3000 samples
	5 Sec	1.7 mS	3000 samples

(*) 30 mSec capture time is not available with this wiring setup. If 30 mSec is selected the actual capture time will be 60 mSec.

The display will then prompt for the volts and amps ranges to be set. The ranges should be set higher than the maximum peak input likely to occur. For example if an inrush of about 20 amps peak is expected the 50 amp range should be chosen.

When the correct ranges have been set press 'ENTER'.

The next input will be to select either manual or external trigger. Manual trigger is initiated by pressing the 'START' key. External trigger is initiated by shorting the 'integrator ext' input on the rear panel.

The PM3000 will then wait for the trigger to occur. The data log may be abandoned by pressing the 'STOP' key at this stage.

The delay from trigger to the commencement of sampling is in the order of 10 - 20 uS.

After the trigger, the LED under the 'START' key will illuminate to show that the analysis is under way. When the analysis is complete the LED will turn off and the results chosen to be output will be printed.

At the same time the captured waveforms will be presented on the 'analog outputs' connector. If there is a neutral wire the calculated neutral waveform will be output.

An oscilloscope trigger output is also generated.

DATA LOG (CONTINUED)

WIRING	PIN	WAVEFORM
SINGLE PHASE TWO WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	7	SCOPE TRIGGER
	2-16 EVEN	GROUND
SINGLE PHASE THREE WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	13	NEUTRAL
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND
THREE PHASE THREE WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND
THREE PHASE FOUR WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	9	CH3 AMPS
	11	CH3 VOLTS
	13	NEUTRAL
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND

Note that the neutral current will be output on a reduced scale compared to the other phase currents.

DISPLAY MENU

The Display menu allows the user to :

i. Choose the results to be shown on the display top line.

or if multi channel measurements are being made :

ii. Display all channels plus sum simultaneously.

Example

Select WIRING --- 3 Phase 4 Wire
CHANNEL SELECT --- SUM
FUNCTION --- WATTS

Display -

0.0000 V 0.0000 A
Watts = +0.0000 W

Which shows the sum of the Volts, sum of the Amps and sum of the Watts.

Press the 'DISPLAY' key

Display:

SUM DISPLAY MODE
mult <single>

Select <mult> using the SELECT and ENTER keys

The LED under the DISPLAY button will illuminate.

The display will now show

+0.000 +0.000 +0.000
Watts = +0.0000 W

The three numbers on the top row correspond to CH1,CH2,CH3 Watts respectively. The bottom row shows the sum of the Watts.

Press CH1

The display will now revert to showing CH1 Volts CH1 Amps and CH1 Watts.

TO CHANGE THE TOP LINE DEFAULTS

Press the 'DISPLAY' key

Select 'single' Press ENTER

Display:

(Volts)( )
<enter> or <select>

Press 'SELECT' until the required parameter appears in the top left hand window. The parameters allowed are Volts, Amps, Watts, VA, Freq.

Press 'ENTER' and repeat for top left hand window.

THE ENTER KEY

The 'ENTER' key has three functions

i. To enter numeric selections.

ii. To enter menu selections.

ii. It also acts as a hold button to freeze the display.

FAST MODE

This mode will reduce the measurement cycle time by about a factor of two/three when faster response is required. Harmonic analysis is suspended when this mode is enabled and therefore functions that use harmonic values are invalid.

The fast mode is entered from the 'F[6]' function (FUNC SELECT key).

Only the following measurements are valid with fast mode enabled:

EACH PHASE :

WATTS
VA
VARS
VRMS (or MEAN)
ARMS (or MEAN)
FREQ
POWER FACTOR
V PEAK
A PEAK
V CREST FACTOR
A CREST FACTOR
INRUSH AMPS
IMPEDANCE (Z)

SUM :

WATTS

NEUTRAL :

ARMS

INTEGRATOR :

WATT HOURS

NOTE - NO HARMONIC ANALYSIS IS PERFORMED IN THIS MODE OF OPERATION - ALL RESULTS REQUIRING HARMONIC DATA WILL BE INVALID. NO WARNING IS GIVEN IF THESE RESULTS ARE CALLED FOR.

FORMULAE USED IN ANALYSIS FOR EACH PHASE

The samples are taken over an integral number of cycles at a rate determined by the input frequency.

$$\text{VRMS} = \sqrt{\frac{1}{2\pi}\int_{0}^{2\pi} v^2\,dt} \qquad \text{ARMS} = \sqrt{\frac{1}{2\pi}\int_{0}^{2\pi} i^2\,dt}$$

The samples are squared, added together, and the total is then divided by the number of samples. The square root of this number is the true RMS value of the waveform.

$$\text{V MEAN} = \frac{1}{2\pi}\int_{0}^{2\pi} |v|\,dt \qquad \text{A MEAN} = \frac{1}{2\pi}\int_{0}^{2\pi} |i|\,dt$$

The magnitude of each sample is added, the total is then divided by the number of samples to give the MEAN value.

$$\text{TOTAL WATTS} = \frac{1}{2\pi}\int_{0}^{2\pi} (v * i)\,dt$$

The instantaneous volts and amps samples are multiplied and added. The total is divided by the number of samples to give the true power. The polarity indicates direction of power flow.

$$\text{FUNDAMENTAL WATTS} = V(f) * A(f) * \cos\theta$$

The fundamental volts value is multiplied by the fundamental amps value and is multiplied be the cosine of the phase angle. The polarity indicates direction of power flow.

FORMULAE USED IN ANALYSIS FOR EACH PHASE (CONTINUED)

TOTAL VA = $Vrms * Arms$

The VRMS and ARMS results are multiplied to give the VA value.

FUNDAMENTAL VA = $V(f) * A(f)$

The fundamental volts value is multiplied by the fundamental amps value.

TOTAL VAR = $\sqrt{(VA^2 - W^2)}$

The square root of the square of the VA value less the square of the WATTS value.

FUNDAMENTAL VAR = $V(f) * A(f) * Sin\ \theta$

The fundamental volts value is multiplied by the fundamental amps value and is multiplied be the sine of the phase angle.
A negative polarity indicates capacitive VAR.
A positive polarity indicates inductive VAR.

TOTAL POWER FACTOR = $\frac{W}{VA}$

The total WATTS divided by total VA.

FUNDAMENTAL POWER FACTOR = $\frac{W(f)}{VA(f)} = Cos\ \theta$

The fundamental WATTS divided by fundamental VA.
A negative polarity indicates lagging power factor (inductive).
A positive polarity indicates leading power factor (capacitive).

HARMONIC VARS = $\sqrt{VAr^2 - VAr(f)}$

The square root of the square of the total VAR value less the square of the fundamental VAR value.

Note: This value is not displayed but is used in multiphase analysis.

FORMULAE USED IN MULTIPHASE ANALYSIS

In multiphase systems the standard convention of vector power factor is assumed: eg all fundamental components are added vectorially.

SUMMATION OF TOTAL WATTS = $W_1 + W_2 + W_3$

The sum of the individual phase watts.
The polarity indicates the direction of power flow.

SUMMATION OF FUNDAMENTAL WATTS = $W(f)_1 + W(f)_2 + W(f)_3$

The individual phase fundamental watts are added.
The polarity indicates the direction of power flow.

SUMMATION OF TOTAL VARS = $\sqrt{\sum VAr(f)^2 + \sum VAr(H)^2}$

The square root of the square of the sum fundamental VAR value plus the square of the sum harmonic VAR value.

SUMMATION OF FUNDAMENTAL VARS = $VAr(f)_1 + VAr(f)_2 + VAr(f)_3$

The sum of the individual phase fundamental VARs.
A negative polarity indicates capacitive VAR.
A positive polarity indicates inductive VAR.

SUMMATION OF TOTAL VA = $\sqrt{\sum W^2 + \sum VAr^2}$

The square root of the square of the sum total WATTS value plus the square of the sum total VAR value.

SUMMATION OF FUNDAMENTAL VA = $\sqrt{\sum W(f)^2 + \sum VAr(f)^2}$

The square root of the square of the sum fundamental WATTS value plus the square of the sum fundamental VAR value.

FORMULAE USED IN MULTIPHASE ANALYSIS (CONTINUED)

SUMMATION OF TOTAL POWER FACTOR = $\frac{\sum W}{\sum VA}$

The sum total WATTS divided by the sum total VA.

SUMMATION OF FUNDAMENTAL POWER FACTOR = $\frac{\sum W(f)}{\sum VA(f)}$

The sum fundamental WATTS divided by the sum fundamental VA.
A negative polarity indicates lagging power factor (inductive).
A positive polarity indicates leading power factor (capacitive).

SUMMATION OF HARMONIC VARS

SINGLE PHASE THREE WIRE AND THREE PHASE FOUR WIRE

$$= |VAr(H)_1| + |VAr(H)_2| + |VAr(H)_3|$$

The sum of the magnitudes of the individual phase harmonic VARs.

THREE PHASE THREE WIRE

$$= \frac{\sqrt{3}}{2}\left(|VAr(H)_1| + |VAr(H)_2|\right)$$

Root three over two times the sum of the magnitudes of the individual phase harmonic VARs.

Note: This value is not displayed but is used in multiphase analysis.

SUMMATION OF VOLTS

SINGLE PHASE THREE WIRE = 183W $\sum V = V_1 + V_2$

THREE PHASE THREE WIRE = 383W $\sum V = \frac{V_1 + V_2}{2}$

THREE PHASE FOUR WIRE = 384W $\sum V = \frac{V_1 + V_2 + V_3}{3}$

SUMMATION OF AMPS

SINGLE PHASE THREE WIRE = 183W $\sum A = \frac{\sum VA}{\sum V}$

THREE PHASE THREE WIRE = 383W $\sum A = \frac{\sum VA}{\sqrt{3} * \sum V}$

THREE PHASE FOUR WIRE = 384W $\sum A = \frac{\sum VA}{\sqrt{3} * \sum V_{L-L}}$ or $\frac{\sum VA}{3 * \sum V_{L-N}}$

FREQUENCY SOURCE

In order to correctly analyse all the functions available on the PM3000 it is necessary to determine the frequency of the ac input. The frequency source for this measurement may be selected by pressing the 'FREQ SOURCE' key.

There are three options:

1. CH1 Volts with a frequency range of dc and (5 Hz - 30 kHz)

ii. CH1 Amps with a frequency range of dc and (5 Hz - 30 kHz)

iii. EXTERNAL with two ranges -

SLOW SAMPLING MODE OFF	dc and (5 Hz to 100 kHz).
SLOW SAMPLING MODE ON	0.1 Hz to 100 kHz.

Selecting the EXTERNAL range 0.1 Hz to 100 kHz will give measurement cycle times in excess of 25 seconds for frequencies under 5 Hz.

The maximum voltage to be applied to the EXTERNAL input is 50 Vpk.

EXTERNAL is not a valid option in data log. The data log function will revert to CH1 volts as the source if EXTERNAL was the source when the 'DATA LOG' key was pressed.

FUNDAMENTAL (FUND) KEY

The PM3000 will normally display results as true RMS values. This takes into account harmonics, noise, offsets etc.

Pressing the fundamental key will return results calculated by using the fundamental components of voltage and current only.

For example FUND PF will calculate the power factor due to the phase shift between the voltage and current fundamentals. TOTAL PF on the other hand takes into account phase AND distortion and for many non linear loads will give a low power factor when there is little or no phase shift.

HARMONIC ANALYSIS

The PM3000 will measure the harmonic content of the voltage and current for all components up to the 50th harmonic. It will also analyse the current flowing in the neutral and will calculate any dc components.

The magnitude of the fundamental is presented in volts or amps rms, while harmonics 2 - 50 are given as a percentage of the fundamental. Harmonic 0 (dc) is also calculated and is presented as dc volts or dc amps.

The phase angle of harmonics 1 - 50 is also calculated, and is always referenced back to the volts ch1. The phase angle is given in the range 0 to -360 degrees and relates directly to the harmonic in question.

To obtain the harmonic information the PM3000 performs a discrete Fourier analysis at each harmonic frequency. This will give excellent results even when the harmonic component is very small.

In order to analyse the harmonics succesfully it is important the the frequency of the fundamental is correctly determined. Press the 'FREQ' key to check that the frequency is correct. The PM3000 is able to extract the fundamental frequency from volts, amps or external sources.

The results can be read from the display or multiple harmonics can be sent to the printer.

To read a harmonic from the display press either the 'V HARM' or 'A HARM' key and enter the required harmonic (max 50). The fundamental will be displayed on the top line and the harmonic requested on the bottom line as a percentage of the fundamental.

To view another harmonic press the 'VHARM' or 'A HARM' key again and enter another harmonic number. Alternatively press the 'SELECT' key and the next order harmonic will be selected and displayed.

To get a printout of all harmonics up to a preset limit use the printer selection menu. A choice of printing all the harmonics or odd harmonics only is available. The results are followed by the thd calculated from the percentages of the harmonics chosen.

HARMONIC DISTORTION MEASUREMENTS

The distortion factor of a waveform can be measured by pressing the V DF or A DF keys. The result is obtained by the calculation

$$df = \sqrt{(RMS^2 - H1^2)} \ / \ H1$$

where H1 is the fundamental component.

This measurement takes into account all distortion including noise and dc offsets.

This will give very good results with waveforms having greater than 2% distortion. An alternative method which works well with distortion under 2%, is to measure individual harmonics and calculate the thd with the formula

$$thd = \sqrt{H2^2+H3^2+H4^2+H5^2+H6^2.....}$$

where H2 is the 2nd harmonic percentage, H3 is the third harmonic percentage etc.

A printout of all selected harmonics up to 50 is easily obtained with the PM3000 (see Harmonic Analysis), and the thd is automatically printed out after the individual harmonics.

Only the distortion factor measurements (V DF, A DF) are available on the front panel display, the thd of selected harmonics is obtainable with a printout or over the IEEE bus only.

INTEGRATOR

The PM3000 can analyse energy consumption or maximum demand with its comprehensive integrator facility. The measurements may be viewed on the front panel display and can be printed if desired.

The normal operation of the PM3000 is not interrupted by running the integrator.

The integration period can be controlled in three ways.

i. Front panel control (integrator START / STOP keys)

ii. External control (integrator ext trigger on rear panel)

iii. Timed operation (either cyclic or timeband control)

FRONT PANEL CONTROL

Press the integrator menu key and enable the integrator, then select 'TRIGGER' control. Enter 'MANUAL' trigger and the LED under the integrator key will illuminate to show that the integrator is ready to be triggered.

To start the integrator press the 'INTEGRATION START' key. The LED under the start key will turn on to show that the integrator is running. Pressing any of the integration function keys will give the run time in 0.0001 hour units and the integrated function.

The integrator can now be reset or stopped.

To reset press the INTEGRATOR START/RESET key again. The integrator will be reset and restarted. The terminal results are not available on the front panel display but will automatically be sent to the printer if the interface is enabled (see integrator printouts).

To STOP the integrator press the INTEGRATOR STOP key. The LED under the START key will turn off and the integrator will stop. The terminal results are held and can be viewed from the front panel display, and will automatically be printed if the printer interface is enabled.

The integrator can be restarted at this point by pressing 'START' again or can be disabled by pressing the integrator menu key and selecting 'DISABLE'.

TO SET AN EXTERNAL TRIGGER

Press the integrator menu key and enable the integrator, then select 'TRIGGER' control. Enter 'EXTERNAL' trigger and the LED under the integrator key will illuminate to show that the integrator is ready to be triggered.

The integrator will start when the integrator external input on the rear panel is grounded. The integrator will run all the time this input is low. To stop the integrator release the input. The terminal results may then be viewed on the front panel display and will automatically be printed out if the printer interface is enabled.

The integrator can be reset and restarted at this point by grounding the external input again or can be disabled by pressing the integrator menu key and selecting 'DISABLE'.

INTEGRATOR (CONTINUED)

TO SET UP TIMED CONTROL

Press the integrator menu key and enable the integrator, then select 'TIME' control. A start date can now be entered, for today just press 'ENTER'. The start time is the next prompt, to start immediately press 'ENTER'.

A stop date and time can then be input, press 'ENTER' if no stop time is required.

If a stop date has been entered a prompt will ask if resets are required. If the integrator has just to run between start time and stop time then select no resets. The integrator will then run until the stop time and stop. The terminal results may then be viewed on the front panel display and will automatically be printed out if the printer interface is enabled.

TO SET RESETS

Resets can be 'CYCLIC' or 'TIMEBAND'.

'CYCLIC' will reset and start the integrator at a user defined interval and will need the printer interface enabled to print the terminal results.

'TIMEBAND' will reset and start the integrator at user programable times, up to five times may be set, and will be useful for monitoring and costing consumption over different tariff bands. The printer interface will also have to be enabled to print the terminal results.

INTEGRATOR ---- SETTING TIMEBANDS

Set up to 5 timebands - each timeband has to be set in order from a 24 hour clock point of view.

e.g. if three timebands required
17:00 - 02:00
02:00 - 08:00
08:00 - 17:00

Then timeband
1 = 02:00 - 08:00
2 = 08:00 - 17:00
3 = 17:00 - 02:00

The start and stop dates can be set to control the the total integration period.

INTEGRATOR ------ PRINTOUTS

The integrator results can be printed in two ways :

i. Stop the integrator and read or print out the results from the display. This will not be possible if the integrator is in a cyclic or timeband mode where the next integration period will start immediately.

ii. Enable the printer before the integrator resets and all the results will be dumped automatically to the printer. This will not affect any other printer operation (such as timed printouts).

Totals can be read from the front panel display at any time during the integration period without affecting the operation of the integrator.

INTEGRATOR (CONTINUED)

CORRECTION VARS

An integrator function which displays the value of the VArs required to correct the average power factor to a target power factor preset by the user.

To set the target power factor press the 'F' key then the 'SELECT' key to select F[2]. Press 'ENTER'. Then enter the target power factor using the numeric keys. To change the sign press the 'SELECT' key.

Note that the 'FUND' LED illuminates when 'CORR VAr' is selected.

The correction will calculate the VArs necessary to provide the phase shift required to reach the target power factor, it does not compute total VArs.

For example, if a poor power factor is due solely to distortion, no amount of phase lead or lag will improve it, and the correction VArs value will be low, as the fundamental power factor is unity.

INRUSH CURRENT

The 'INRUSH A' key on the PM3000 allows the user to capture and hold the peak current of all three current channels. This feature is typically used to display the peak inrush current at switch on of power supplies and motors etc.

To measure inrush current:

Press the 'INRUSH A' key.

Select an amps range that is able to accommodate the expected peak inrush current. Switch on the load. The display will show the highest current captured. If the load is multi-phase the inrush current on each phase will have been captured and can be viewed with the CH1,CH2 and CH3 'CHANNEL SELECT' keys.

The highest value captured will be held until the 'INRUSH' key is pressed again to reset the display. If an overload occurs the display will not clear until the 'INRUSH' key is pressed even if the overload is no longer present.

The measurement is made by sampling continuously on all three current channels and holding the highest value. The sample rate varies according to the wiring configuration.

WIRING	SAMPLE RATE
Single phase two wire	20uS
Single phase three wire	30us
Three phase three wire	30uS
Three phase four wire	40us

Inrush current can also be measured using the data log function. This has the advantages of allowing the user to view the captured inrush waveforms and of making other measurements on the same data.

IMPEDANCE

The impedance of a load can be measured by pressing the 'IMPEDANCE' key.

If the 'FUND' LED is off the total impedance will be displayed in ohms, calculated as total rms volts / total rms amps.

If the 'FUND' LED is on, the complex impedance due to the fundamental volts and amps will be displayed. This will be in the form of resistance and reactance. E.g. Impedance = +-R +-jX ohms.

+ R indicates power flow into load
- R indicates power flow from load

+ X indicates inductive reactance
- X indicates capacitive reactance

MEAN VOLTS AND AMPS

The PM3000 can display voltage and current in either true RMS or rectified MEAN values.

Only the volts, amps and amp-hours measurements will be changed if MEAN is selected, all other parameters will remain in RMS values. The 'SELECTION' printouts will retain the rms values for volts and amps.

The corrected rectified mean value (MEAN * 1.11) can be obtained by pressing the 'FUND' key and reading the (FUND) MEAN volts and (FUND) MEAN amps.
In this case the value is NOT a fundamental component but MEAN * 1.11.

This feature will be useful for comparing the reading of MEAN reading multimeters which work using this principle.

For example a 110 volt rms sinusoidal input would read:

V rms = 110 volts
V mean = 99 volts
V mean (F) = 110 volts

The corrected mean and rms will only give the same values if the input is a pure sine wave.

A 10 volt rms square wave would read:

V rms = 10 volts
V mean = 10 volts
V mean (F) = 11.1 volts

METHOD OF OPERATION

The PM3000 has 6 isolated input channels (3 voltage - 3 current) with 12 ranges per channel. Each channel has its own a-d converter which samples the input and sends the digital data back to a microprocessor using a pulse transformer link. This technique allow the PM3000 extremely high common mode rejection, minimising the effects caused by high dv/dt waveforms such as exist in motor drives etc.

The sampling is under the direct control of the processor and the analog to digital conversion for all channels is simultaneous (no phasing errors).

The normal measurement procedure is as follows, note that inrush and data log measurements have separate routines.

All channels are sampled at a sample rate set by the microprocessor. The data is stored in memory until 1000 samples for each channel have been made. The data is then checked for over-range or under range. If the range is correct the frequency of the input is calculated. If the sample rate is not right for the input frequency the sample rate is adjusted and 1000 new samples are taken.

The processor then calculates the volts, amps and watts etc for each channel and then performs a Fourier analysis of the data to compute the fundamental components of the volts and amps and any other harmonics required.

This data is then transferred to the interface processor and another set of samples are taken.

The interface processor averages and displays the results required for the front panel display.
Further to this all the results for every phase are computed and averaged and stored in memory. These background results are available to the printer and the IEEE interface.

The user can select over 400 different measurements from this store making the PM3000 an extremely versatile instrument.

PHASE TO PHASE VOLTAGE READINGS

When voltage measurements are made by the PM3000 the value displayed is normally the voltage across the V hi and V lo inputs.

In the case of three phase four wire multi-phase measurements (three wattmeter) this voltage is normally the phase to neutral volts.

In many cases the voltage of interest is the phase to phase voltage, the PM3000 offers the option of displaying this instead of the applied volts.

Press the 'F' key.

Use the 'SELECT' key to give 'F[3] p-p / P-N VOLTS'

Select P-P and press 'ENTER'

With the wiring set to three phase four wire the voltage readings will be from phase to phase.

PRINTER SETUP

The printer output can be standard centronics or RS232.

Centronics is the default but the output will be directed to the RS232 port if the RS232 interface is enabled. If the instrument is used with a computer without an IEEE interface, data can be sent to the computer using the RS232 interface.

When the printer output is enabled the LED under the interface key will illuminate.

The printout data can be from one of three sources:

i. The results currently on the front panel display.

ii. A selection of results from one or more than one channel. In this mode over four hundred results can be programmed to be printed from one measurement cycle.

iii. The integrator results. When the integrator is stopped the results will automatically be output to the printer interface if enabled.

PRINTER SETUP MENU (DISPLAY RESULTS)

To print out the results given on the front panel display:

Press the 'INTERFACE' key and select the printer menu.

Select 'PRINTER ON'

Select 'DISPLAY'

The PM3000 can print after a trigger input, or it can be programmed to print at set intervals.

i. To print with a trigger input:

Select 'TRIGGER'

The trigger can be

a. MANUAL Pressing the 'DATA DUMP' key will action a printout.

b. EXTERNAL Shorting the Ext Trigger input on the rear panel will give a printout.

ii. To print at set intervals:

Select 'TIME'

Enter the print interval in hours and minutes. The PM3000 will enter times without needing the 'ENTER' key. Printouts will then automatically occur at that interval. Additional printouts can me made by pressing the 'DATA DUMP' key.

The printout will mirror the front panel display with the additional information of:

i. The time and date.

ii. AC or AC+DC coupling.

iii. RMS or MEAN volts and amps.

PRINTER SETUP MENU (SELECTION)

To print out a selection of results:

Press the 'INTERFACE' key and select the PRINTER menu.

Select 'PRINTER ON'

Select 'SELECTION'

Using the five 'CHANNEL SELECT' keys along the bottom of the display choose the channels that need their results printed.

Now use the function keys to enter the functions that require printing. For example if power factors are needed to be printed press the 'PF' key.

Do not press 'ENTER' until the selection is complete.

If the fundamental components of V,A,W,PF,VA,VARs etc need to be printed this can now be selected.

As all the basic functions are stored anyway, choosing many results to be printed will not slow the instrument down at all. However, choosing more than the fundamental harmonic of either volts or amps will impose an additional burden on the processor and will lengthen the measurement cycle. In this case the front panel display will no longer be active and the results will have to be obtained from the printer only.

The PM3000 can print after a trigger input, or it can be programmed to print at set intervals.

1. To print with a trigger input:

   Select 'TRIGGER'

   The trigger can be

   a. MANUAL Pressing the 'DATA DUMP' key will action a printout.

   b. EXTERNAL Shorting the Ext Trigger input on the rear panel will give a printout.

ii. To print at set intervals:

Select 'TIME'

Enter the print interval in hours and minutes. The PM3000 will enter times without needing the 'ENTER' key. Printouts will then automatically occur at that interval. Additional printouts can me made by pressing the 'DATA DUMP' key.

The printout will contain all the results selected plus the date and time and whether the coupling is ac+dc or ac.

PROGRAM SWITCH

The program switch facility enables two stored setups to be alternatively loaded with a single key press. This is especially useful in cases where channel 3 is used as a separate input with it's own printer and scaling setups, etc.

To use, save the first setup into P[1], and then reconfigure the instrument for the second setup and save in P[2]. See SETUP PROGRAMS.

Press the 'F' button and choose F[5] PROGRAM SWITCH. Select 'ON'.

Pressing the 'P' button from now on will switch between setup P[1] and setup P[2]. To restore the 'P' button to normal operation use the F[5] function to turn PROGRAM SWITCH 'OFF'.

RANGING

Each channel has twelve ranges which may be manually selected or auto-ranged. In most cases auto ranging will be preferred. In special cases such as inrush current measurements and data logging the range has to be set manually.

To select a manual range press the 'AUTO' key and the LED underneath will turn off.

Press the UP / DOWN arrows under the bar LEDS to move to the required range.

Each range is marked with the PEAK value, which should be taken into account when manually setting the range. E.g. a sinusoidal voltage of 15 V RMS has a 21.2 volt peak. As this peak will exceed the 20 volt range it will require the 50 volt range.

The display will show 'OVERLOAD' if an input is too high for a certain range.

The RS232 port can be used to send results to a printer or computer:

Set up the printer menu to output the required results.
These are by default directed to the centronics interface.

Press the 'INTERFACE' key.

Use the 'SELECT' key to choose the 'RS232' menu. Select 'ENABLE'.

Use the 'SELECT' key to choose the required baud rate. Press 'ENTER'.

The printer output will now be directed to the RS232 port.

The data is output with 1 start bit ,8 data bits ,2 stop bits, no parity. Simple CTS/RTS handshaking is used to control data flow.

RS232 CONNECTOR 25 WAY 'D' SOCKET	PIN	FUNCTION
	1	FRAME GROUND
	2	RXD
	3	TXD
	4	CTS
	5	RTS
	6	DTR
	7	GROUND
	20	DSR

SCALING

The PM3000 readings may be scaled to match the ratio of any voltage or current transducers.

Press the 'SCALING' key and the display top line will show the present voltage scaling factor. If the volts scaling factor is correct press 'ENTER' and the display will then show the amps scaling factor ratio.

If a scaling factor of other than unity is given for either volts or amps the LED under the 'SCALING' key will illuminate.

TO CHANGE A SCALING FACTOR

The display will ask for a new scaling factor.

If a ratio of 1:1 is required just press 'ENTER'. Otherwise input the new scaling factor in the range 1 - 99999, the decimal point may be used. Inputs less than 1 will not be accepted. The numeric entry may be cleared at any time by pressing the 'SELECT' key.

If the amps scaling factor is other than unity the readings may be scaled 'UP' where the readings will be multiplied by the scaling factor, or 'DOWN' where the readings will be divided by the scaling factor.

E.g. if a 1000:1 current transformer is used the amps scaling factor should be set to 1000:1 UP.

SCALING THE EXTERNAL SHUNT

The external shunt input has a range of 0 - 2.5 Vpk.
This corresponds to 12.5mV / amp (2500mV = 200A).

If for example a 0.1 ohm external shunt was used this would give 100mV / amp. The PM3000 amps scaling factor would therefore have to be set to 8:1 DOWN to obtain the required 12.5mV / amp ratio.

If mV / amp < 12.5

$$SF = \frac{12.5}{\text{actual mV/A}} \quad \text{UP}$$

If mV / amp > 12.5

$$\frac{\text{actual mV/A}}{12.5} \quad \text{DOWN}$$

THE SELECT KEY

The 'SELECT' key has four functions

i. It selects a new menu option presented on the display. For example if the display shows :

DATA LOG TRIGGER
manual <external>

Pressing the 'SELECT' key will give

DATA LOG TRIGGER
<manual> external

Pressing the 'ENTER' key now will choose the manual trigger.

ii. It acts as a CLEAR key to cancel any numeric entry.

iii. It will select the next order harmonic viewed on the display.

For example:

It is required to view amps harmonics 3 - 7 on the display.

Press the 'A HARM' key.
Press '3' and then 'ENTER'.
The third harmonic will then be displayed on the bottom line of the front panel display.
Press 'SELECT'.
After a short delay the 4th harmonic will be displayed.
Press 'SELECT' again for the 4th,5th,6th,7th etc.

If only odd harmonics are required the 'SELECT' key can be pressed twice to increment the harmonic number shown by two.

iv. It will also clear a PRINTER HOLD condition - however the printout will be abandoned.

SETUP PROGRAMS

Up to five setups can be stored in the PM3000's non-volatile memory.

The first program (P1) may be automatically loaded on power up to configure the instrument to a user's setup.

Scaling factors, chart recorders, printer setups, display setups etc are all stored when a setup is saved. Integrator settings are not stored.

The 'P' button can also switch the instrument from the P[1] setup to the P[2] setup if the 'PROGRAM SWITCH' function is enabled (see PROGRAM SWITCH).

To save a setup press the 'P' key.

Use the 'SELECT' key to choose to 'SAVE' a program and then select the program number to which the setup is to be saved. Press 'ENTER' and the current configuration is saved in non-volatile memory. This is powered by a lithium battery with a life of at least five years.

TO LOAD A STORED SETUP

Press 'P'

Choose to 'LOAD' a program and use the 'SELECT' key to access the correct program. Press 'ENTER' and the setup will be loaded and the message 'NEW SETUP LOADED' will be displayed.

If no program has ever been loaded into that store or the data has been corrupted, the load will be cancelled and the program will exit the menu.

TO PROGRAM P(1) AS THE POWER ON DEFAULT

The contents of the first program store P(1) can be made the power on default setup.

To do this press the 'F' key.

Select F[1] 'POWER ON DEFAULT' and use the 'SELECT' key to choose P[1].

Press 'ENTER'.

Until the default is changed back to 'STANDARD' the PM3000 will power up with the setup stored in P(1).

PM3000 UNIVERSAL POWER ANALYSER CALIBRATION PROCEDURE

VERSION 3.01

1. CALIBRATION OVERVIEW

All calibration constants are stored in EEPROM, allowing the PM3000 to be calibrated without having to remove the cover.

The calibration sequence is passcode protected and may be performed manually or via the IEEE interface.

All three voltage or current inputs are calibrated simultaneously for maximum efficiency.

The integrity of the EEPROM contents is checked at power on and an 'UNCALIBRATED' message is displayed if the contents are invalid.

The EEPROM is not affected by the state of the battery and will retain its data for at least 10 years.

2. THE PASSCODE

The passcode is a 4 digit number that allows entry to the calibration routines. It comes factory set at '3000', but may be changed by the user for extra security.

If the new code is lost or forgotten then a master code is held at Voltech to allow access. Contact Voltech or your dealer if this is needed.

TO CHANGE THE PASSCODE

Press the 'F' button.

Press the 'Select' button until 'F[9] CALIBRATION' is displayed.

Press 'Enter' to select the calibration program.

Display =

```
Cal Code?  0-9999
                0.
```

Enter the old 4 digit passcode. If this is incorrect you will be returned to the main program.

Display =

```
ENTER NEW CAL CODE?
     yes <no>
```

Use the 'Select' key to prompt <yes> and press 'Enter'

Now input the new code and press 'Enter'

The new code is now saved in EEPROM. If the PM3000 does not require recalibration the instrument may be switched off at this point.

3. MANUAL CALIBRATION

Switch on the PM3000 and allow sufficient time for the unit to reach a stable temperature (minimum 15 minutes).

Connect a printer to the PM3000 centronics port. A printer is required even if the interface is disabled in the interface menu.

Press the 'F' button.

Press the 'Select' button until

Display =

F[9] CALIBRATION
<enter> or <select>

Press 'Enter' to select the calibration program.

A valid passcode (4 digits) is required to proceed further. The code is factory set to '3000' but may be changed by the user (see previous section). Key in the code and press 'Enter'. If the code is incorrect the calibration will be terminated.

Display =

CALIBRATE VOLTS?
<yes> no

Press 'Enter' for the Voltage calibration routines.

Press 'Select' and then 'Enter' if the Voltage channels do not need calibration.

4. VOLTAGE RANGES CALIBRATION

Display =

```
INPUT   200 mV rms
VALUE =         0.
```

The printer will output -

```
*Volts Cal*
Range 01
```

If you wish to skip the calibration of this range press 'Enter' and the program will move on to the next range.

To calibrate the range set the generator output to approximately the value requested on the display (+- 10%).

Allow to settle and key in the measured value from the DMM. Enter data in the units displayed eg mV (ranges 1-3) or Volts (ranges 4-12).

Press 'Enter'. The voltage will be measured on all three inputs and the calibration constants for each card will be calculated and printed.

If the calibration constant deviates from the nominal by more than a fixed percentage, the result will be prefixed by an asterix '*' and will not update the calibration constant in memory.

Repeat for all twelve ranges.

The display will then show -

```
CALIBRATE AMPS?
  <yes> no
```

If only the Voltage channels require calibration select 'no' and move to the 'Save data?' prompt.

The Amps channels may now be calibrated by selecting 'yes'.

CALIBRATION (CONTINUED)

5. AMPS RANGES CALIBRATION

Display =

```
INPUT  20.0 mA rms
VALUE =         0.
```

The printer will output -

```
*Amps Cal*
Range 01
```

If you wish to skip the calibration of this range press 'Enter' and the program will move on to the next range.

To calibrate the range set the generator output to approx the value requested on the display.

Allow to settle and key in the measured value from the DMM. Enter data in the units displayed. eg mA (ranges 1-6) or Amps (ranges 7-12).

Press 'Enter'. The Current will be measured on all three inputs and the calibration constants for each card will be calculated and printed.

If the calibration constant deviates from the nominal by more than a fixed percentage, the result will be prefixed by an asterix '*' and will not update the calibration constant in memory.

Repeat for all twelve ranges.

The display will then show -

```
CALIBRATE EXT I/P?
    <yes> no
```

The external inputs may now be calibrated by selecting 'yes'.

If you do not need to calibrate the external input select 'no' and move to the 'Save data?' prompt.

6. EXTERNAL INPUT CALIBRATION

Display -

```
Ext Input 125.00mV
VALUE           0.
```

Input approx 125 mV to all external inputs and key in the value measured by the DMM (in mV units).

Press 'Enter'

The calibration constants will be calculated and printed.

Display -

```
SAVE NEW CAL DATA?
   <save>  quit
```

To save any new calibration data select 'save'. 'quit' will return without altering the EEPROM contents.

7. NOMINAL CALIBRATION CONSTANTS

VOLTAGE RANGE			NOMINAL
1-3	500 mV, 1V, 2V	=	1953
4-6	5V, 10V, 20V	=	2441
7-9	50V, 100V, 200V	=	3051
10-12	500V, 1000V, 2000V	=	1907

AMPS RANGE			NOMINAL
1-3	50mA, 100mA, 200mA	=	3125
4-6	500mA, 1A, 2A	=	1953
7-9	5A, 10A, 20A	=	2441
10-12	50A, 100A, 200A	=	3051

RECOMMENDED EQUIPMENT

1. Datron 1271 or equivalent. (High accuracy true rms digital volt meter).

2. Current Generator

   Voltage 0 - 30 Amp.
   Frequency 60 Hz.

3. Voltage Generator

   Voltage 0 -1000 Volts
   Frequency 60 Hz.

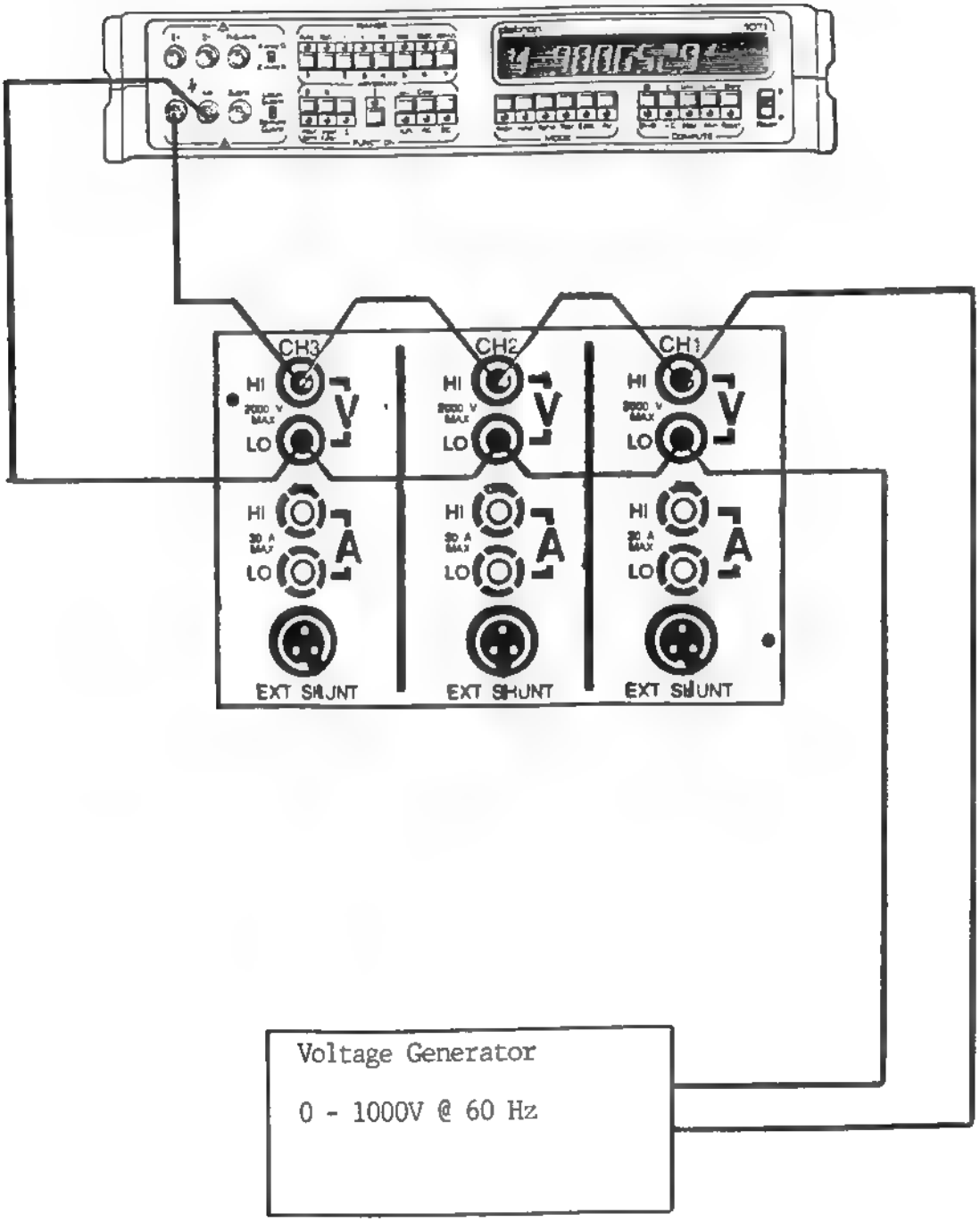
4. Shunts

   a) Resistance 1.0000 Ohm
      Current 2.0 Amp

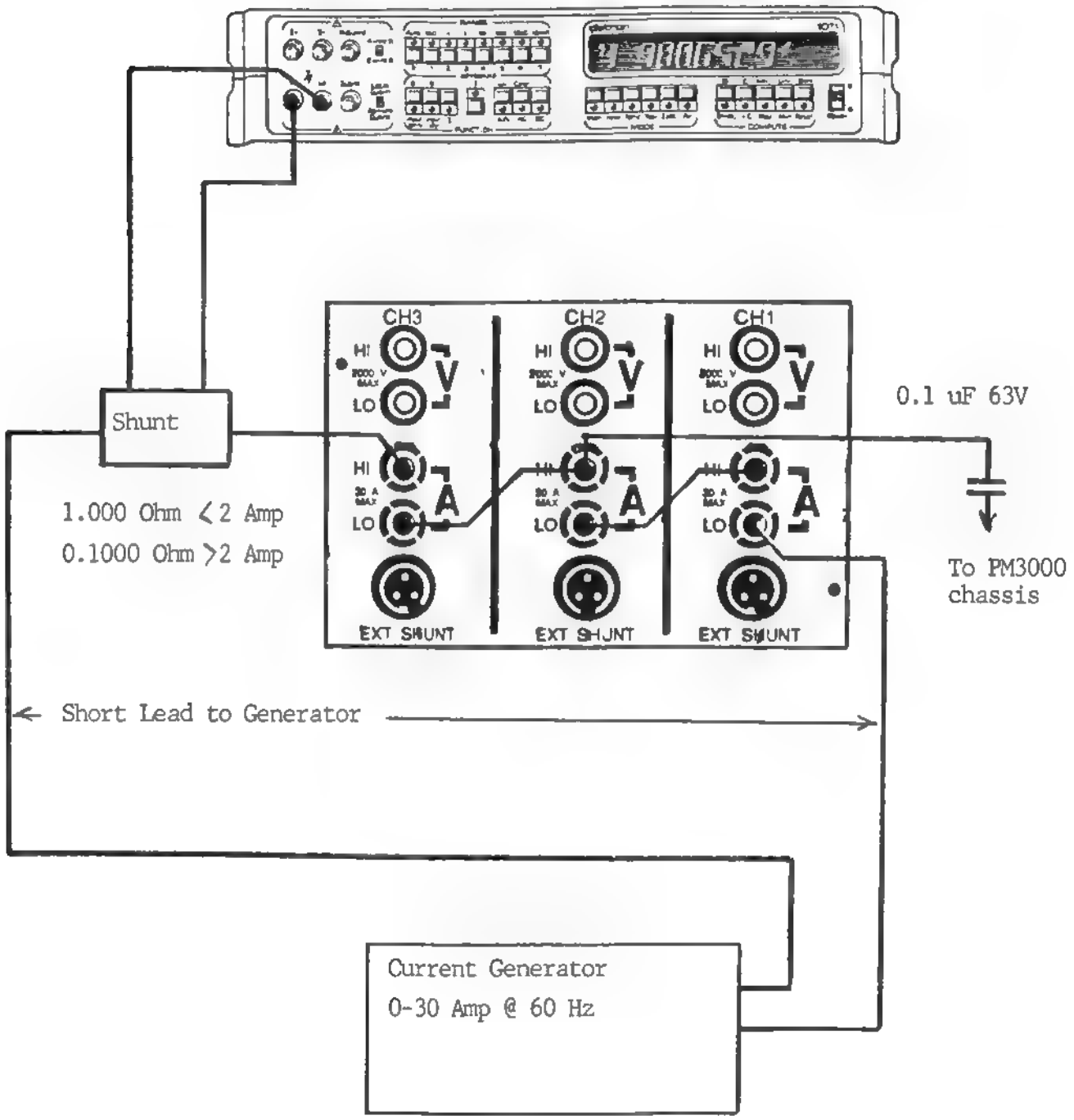
   b) Resistance 0.10000 Ohm
      Current 40 Amp

5. Printer (Centronic Interface)

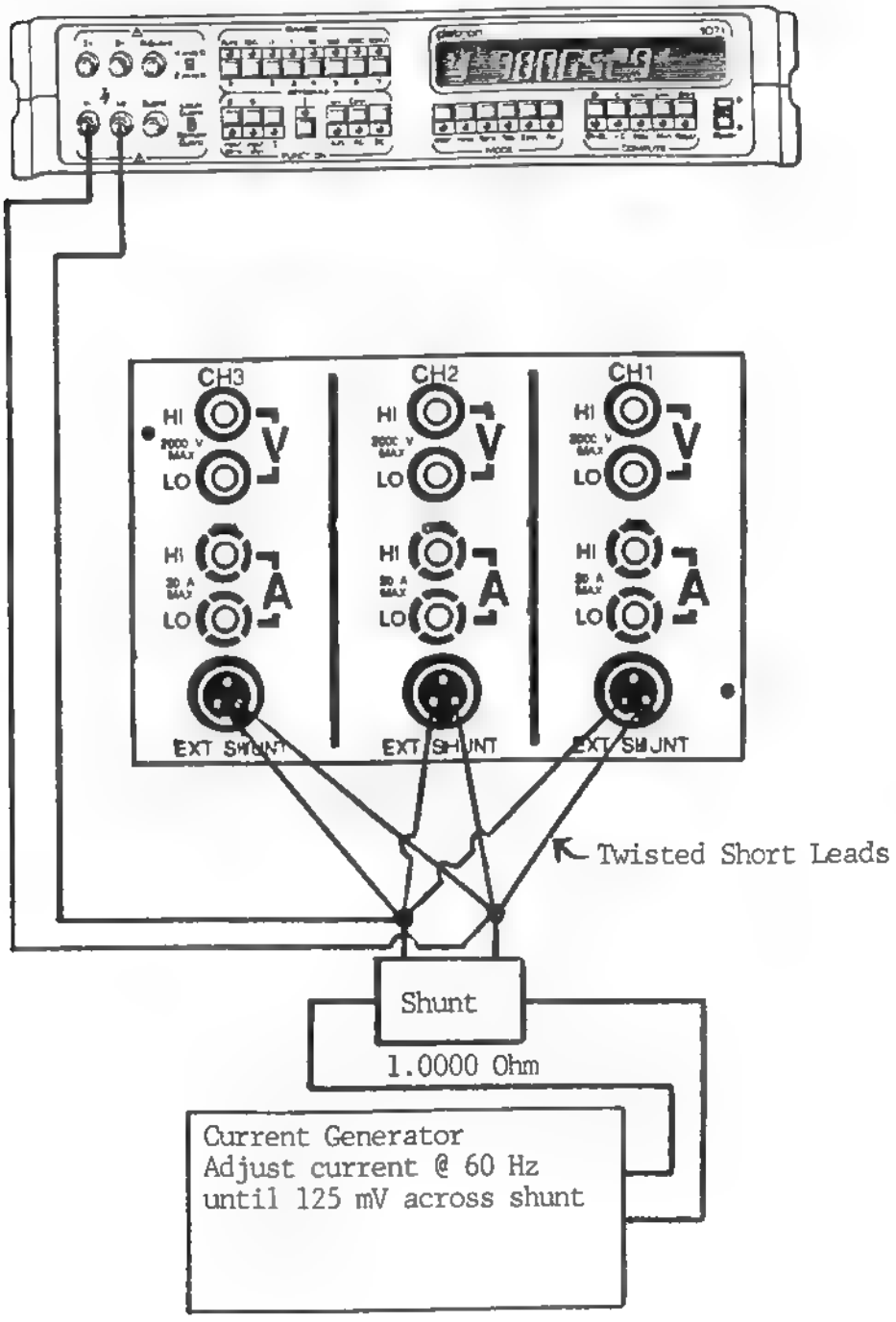
VOLTAGE CALIBRATION



CURRENT CALIBRATION.



EXTERNAL CURRENT CALIBRATION



PM3000 UNIVERSAL POWER ANALYSER IEEE-488

VERSION 3.01

The PM3000 IEEE-488 interface is a full talker listener as defined by the IEEE Standard 488-1978.

It implements the following interface functional subset:

SH1	Source Handshake complete capability
AH1	Acceptor Handshake complete capability
T6	Basic Talker, with serial poll and unaddress with MLA
TE0	No extended Talker
L4	Basic Listener, unaddress with MTA
LE0	No extended Listener
SR1	Service request complete capability
RL1	Remote-Local complete capability
PP0	No parallel poll capability
DC1	Device Clear complete capability
DT1	Device Trigger complete capability
C0	No controller capability

The IEEE-488 bus consists of a controller (e.g. a computer with an IEEE card) and one or more instruments. These may be talkers (able to send results) or listeners (able to receive commands) or talker-listeners (able to receive commands and send results). The PM3000 is a talker-listener.

Each instrument has an address by which it it recognised on the bus. The PM3000 has a default address of 9 which may be altered from the front panel (Interface menu).

When the PM3000 is addressed as a talker results may be read by the controller.

When the PM3000 is addressed as a listener it will respond to commands sent by the controller.

After the PM3000 has been addressed the 'REMOTE' LED will illuminate and the keyboard will be locked out. It is possible to return to front panel control by pressing the 'LOCAL' key.
The controller can send a LOCAL LOCKOUT command which will disable the 'LOCAL' key if required.

The PM3000 may send information from three different sources.

i. Display buffer

The contents of the front panel display will be sent. This is the default.

ii. Background results buffer

When the PM3000 takes a measurement it computes not just the three or four results to be viewed on the front panel display, but also a result for all the functions on every active channel. These are stored and averaged in the background results buffer and are available over the IEEE bus.

iii. Integrator results buffer

When the integrator is stopped the results for all active channels are automatically stored in the integrator results buffer.

Results only become available at the end of a measurement cycle. The duration of each cycle normally varies from 0.5 - 1 second. This time will increase if more than one harmonic is to be analysed or the input frequency is very low.
e.g. A 0.1Hz input will take at least 25 seconds between results.

If a new result is not available the PM3000 will return an empty string (just a line feed).

All strings end with a line feed (10 Decimal, 0A HEX) and EOI asserted.

The following pages contain a list of the commands available to control the operation of the PM3000.

Terminate command strings with a line feed or assert EOI (End or Identify) with the last byte.

When more than one command is sent in the same line they are operated on in the order they are received.

The B,X,J and K commands (Data Output,Data-Log and Scaling Factors) should be sent separately or as the last command in a string.

Do not insert spaces or delimiters between commands.
e.g 'P3C2F01' is ok, but 'P3 C2 F01' is invalid

The commands should be sent upper case only.
e.g. 'P1' is ok, but 'p1' is invalid and will not be recognised.

COMMAND SUMMARY

A - Averaging

B - Results Source

C - Channel Select

D - Display Format

E - Phase-Phase / Phase-Neutral Switch (3 phase 4 wire only)

F - Function Select

G - Fast mode on/off

H - Individual Harmonics

I - Integrator on/off

J - Amps Scaling Factor

K - Volts Scaling Factor

L - Multiple Harmonics

M - Service Request on/off

N - AC / DC Coupling Select

O - Mean or RMS Volts Select

P - Phase Select

Q - Frequency Source Select

R - Range Select

S - Internal / External Shunt Select

T - Trigger

U - Parallel Port Control

V - Not Used

W - Analog outputs

X - Data Logging

Y - Fundamental Select

Z - Calibration

AVERAGING SELECTION

FORMAT A [00-64]

This command selects the display and background averaging.

A00 Selects auto averaging. (16)

A01-A64 Selects the number of display and background averages. The background averaging will limit at 16.

This command resets the display and background averaging.

DATA OUTPUT CONTROL

FORMAT B [0]
B [1] _xx_x_xxxxxxxxxxxxxxxxxxxxxxx
B [2]
B [3]

These commands specify the origin of the data to be returned when the PM3000 is read.

B0 Will return the contents of the 40 character display buffer. The results seen on the display will be returned in a 40 character string followed by a line feed.

The buffer may only be read once each measurement cycle and will return a single line feed on each subsequent read until new data is available.

This mode is the default on power up.

B1 This allows the full versatility of the instrument to be utilised on the IEEE bus. Over 400 different measurements may be initialised with this one command.

There are 27 arguments in three fields consisting of:

i. Channel Select (2 digits)
This field comprises the decimal addition of the following:

01	Ch 1 results
02	Ch 2 results
04	Ch 3 results
08	SUM results
16	Neutral results

e.g. To select results from Channels 1 and 2 only the string to send would be:
B1 03 x xxxxxxxxxxxxxxxxxxxxxxx

To select results from Channels 1 and 2 and Neutral:
B1 19 x xxxxxxxxxxxxxxxxxxxxxxx

To select results from Channel 3 only send:
B1 04 x xxxxxxxxxxxxxxxxxxxxxxx

ii. Select fundamental components (1 digit)

B1 xx 1 xxxxxxxxxxxxxxxxxxxxxxx will store the fundamental components of those functions where the PM3000 computes the fundamental.

B1 xx 0 xxxxxxxxxxxxxxxxxxxxxxx will not store fundamental components.

DATA OUTPUT CONTROL (CONTINUED)

iii. Select function (24 digits)

Digit 1 selects Watts, digit 2 selects VA etc
To select the function write 1 , write 0 if not required.

Position Table:

1. Watts
2. VA
3. Vars
4. Volts
5. Amps
6. Power Factor
7. Volts Peak
8. Amps Peak
9. Volts Crest Factor
10. Amps Crest Factor
11. Not Used
12. Impedance
13. Not Used
14. Not Used
15. Not Used
16. Not Used
17. Not Used
18. Not Used
19. Not Used
20. Voltage Harmonics
21. Amps Harmonics
22. Volts Distortion Factor
23. Amps Distortion Factor
24. Frequency

e.g. To store Ch 1 Watts,Volts,Amps and Freq (no fundamentals):
B1 01 0 10011000000000000000001

Ch 1,2,3 Volts, Amps, V Peak, A Peak, V DF, A DF (with fundamental Volts and Amps):
B1 07 1 00011011000000000000110

Ch 1,2,3,SUM,Neutral Volts, Amps, Freq, Amps Harmonics 0-20 (no fundamentals)
B1 31 0 00011000000000000001001 and then send 'L20 0' to set the maximum harmonic at 20. The total harmonic distortion of the current waveform caused by the harmonics 2 - 20 will follow the last individual harmonic.

Once the B1 command has been set the PM1000 will measure and average all the functions selected.

However nothing will be entered into the results store until a trigger command 'T1' is sent. At the end of the next measurement cycle the averaged results will be stored and may be read sequentially over the bus.

A further trigger 'T1' will enable the store to receive a new set of results at the end of the next measurement cycle.

The B1 command should not be used in a multi line command.

B2 Allows access to the integrator result store.

The integrator store is filled by the integrator stop 'I0' command, and can be read sequentially following 'B2'.

The integrator results (inc fundamentals) for all phases are stored automatically by 'I0' (integrator stop).

B3 Only use after Data Log to access the individual samples. See DATA LOG.

CHANNEL SELECT

FORMAT C [1-5]

Selects the displayed Channel

C1	Channel 1
C2	Channel 2
C3	Channel 3
C4	SUM
C5	NEUTRAL

This function will have no effect if the selection is invalid. (eg if WIRING is configured for single phase two wire and 'C4' (SUM) is sent).

This command will reset the display averaging.

DISPLAY SETUP

FORMAT DL [0-4]
DR [0-4]
DM [0-1]

This command will configure the display.
DL will set the top left hand display window
DR will set the top right hand window
DM will set the SUM display mode. (See display menu)

These commands will reset the display averaging.

The options are:

Top Left Hand Window

DL0	Volts
DL1	Amps
DL2	Watts
DL3	VA
DL4	Frequency

Top Right Hand Window

DR0	Volts
DR1	Amps
DR2	Watts
DR3	VA
DR4	Frequency

Sum Display Mode

DM0	Allows all three channels plus sum to be displayed
DM1	Sets the SUM Display mode to single

THREE PHASE FOUR WIRE VOLTS MEASUREMENT -
PHASE TO PHASE OR PHASE TO NEUTRAL

FORMAT E [0-1]

Selects the voltage measurement system for 3 phase 4 wire measurements only.

E0 Selects phase to neutral voltage measurements

E1 Selects phase to phase voltage measurements

If 3 phase 4 wire measurements are being made E0 or E1 should be sent at the start of the program to ensure the correct voltage measurements are taken.

These commands have no relevance for any other wiring configuration.

SELECT FUNCTION

FORMAT F [00-23]

The main measurement function (bottom row of the display) may be selected with this command. The leading zero is necessary.

The functions are:

F00	Watts
F01	VA
F02	Var
F03	Volts
F04	Amps
F05	Power Factor
F06	Volts Peak
F07	Amps Peak
F08	Volts Crest Factor
F09	Amps Crest Factor
F10	Inrush Current
F11	Impedance
F12	Watt Hours
F13	VA Hours
F14	Var Hours
F15	Ampare Hours
F16	Average Power Factor
F17	Correction Vars
F18	Toggle Fundamental
F19	Voltage Harmonics
F20	Current Harmonics
F21	Voltage Distortion Factor
F22	Current Distortion factor
F23	Frequency

FAST MODE

FORMAT G [0-1]

Sets the PM3000 to the fast mode of operation (no harmonic analysis), where measurement times are reduced by a factor of two/three.

Results needing harmonic data will not be valid in this mode.

See operaters manual for a list of valid functions.

G0	Fast mode off (default)
G1	Fast mode on

SINGLE HARMONICS

FORMAT H [00-50]

Use in conjunction with F19 and F20 To read individual Harmonics.
Send Hxx and then F19 for V Harm xx or F20 for A Harm xx.

For example 'H05F19' programs the instrument to display the voltage harmonic 5

This command resets the display averaging.

H00	Harmonic 0 (dc)
H01	Fundamental component only
H02-50	Harmonics 2 - 50

See DATA OUTPUT CONTROL for multiple harmonics.

INTEGRATOR CONTROL

FORMAT I [0-1]

This command allows control of the integrator function.

I1 Starts integration

I0 Stops integration and stores all integrator values in the integrator result store. The contents of the store may then be accessed with the B2 command (see Data output control).

The integrator results may be read on the fly from the display at any time by the F12-F17 commands.

AMPS SCALING FACTORS

FORMAT J [D-U][1-99999]

Sets amps scaling factors for all three channels.
Scaling up (JU) will multiply the result by the scaling factor.
Scaling down (JD) will divide the result by the scaling factor.

JU1000	Scale Amps up by 1000:1
JD10.5	Scale Amps down by 10.5:1
JU1	Set Scaling Factor 1:1

Scaling factor may not be less than one and may be no more than 5 digits plus decimal point.

The 'SCALING' LED will illuminate if a scaling factor of other than 1:1 is set for volts or amps.

This command must not be used in a multi command line. Any commands following this will not be recognised.

VOLTAGE SCALING FACTORS

FORMAT KU[1-99999]

Sets voltage scaling factors for all three channels

KU1000	Scale Volts up by 1000:1
KU10.5	Scale Volts up by 10.5:1
KU1	Set Scaling Factor 1:1

Scaling factor may not be less than one and may be no more than 5 digits plus decimal point.

There is no command to scale the volts down.

This command must not be used in a multi command line. Any commands following this will not be recognised.

MULTIPLE HARMONICS

FORMAT L [00-50] [0-1]

Use after the B1 command where V Harmonics and/or A Harmonics have been selected. All the harmonics up to and including the limit [00-50] will be analysed and averaged.

The second field selects odd harmonics only to be returned.

L00 0 Will return dc component and fundamental only
L01 0 Will return fundamental component only

L02 0
 ¦ Will return dc,fundamental and all harmonics up to
L50 0 the limit followed by the total harmonic distortion.

L02 1
 ¦ Will return odd harmonics only up to the limit
L50 1 followed by the total harmonic distortion.

e.g. 'L17 1' will analyse harmonics 1,3,5,7,9,11,13,15 and 17 plus the thd.

'L08 0' will analyse harmonics 0,1,2,3,4,5,6,7 and 8 plus the thd.

SERVICE REQUEST ENABLE

FORMAT M [0-1]

Enables or disables the service request.

M0	disables service request
M1	enables service request on data ready

After the 'M1' command the service request line will be asserted when data is ready to be read.

The PM3000 will return a status byte after a serial poll.
This byte has the following significance.

bit	0	data ready
bit	1	background averaging has reached maximum
bit	2	display averaging has reached maximum
bit	3	not used
bit	4	not used
bit	5	not calibrated or calibration corrupted
bit	6	set if service requested
bit	7	not used

e.g.	01	means new data is ready
	65	means data is ready and the srq line has been asserted
	00	no data is ready

AC / DC COUPLING SELECTION

FORMAT N [0-1]

This command selects ac or dc coupling.

N0 AC+DC coupling is selected.
N1 AC coupling is selected. There is a 1 Sec delay after this instruction is executed.

This command resets the display and background averaging.

SET MEAN OR RMS VOLTS AND AMPS

FORMAT O [0-1]

Set the Volts and Amps results to read in either RMS or MEAN terms.

00	Set to RMS
01	Set to MEAN

This command will be inoperative if the integrator is running.

The display averaging will be reset by this command.

WIRING SELECT

FORMAT P [1-5]

Selects the wiring configuration

This command resets the display and the background averaging.

P1 Sets single phase two wire
P2 Sets single phase three wire
P3 Sets three phase three wire
P4 Sets three phase four wire
P5 Sets the channel 3 only mode

After sending P4 (3 phase 4 wire) it is recommended that either the E0 (phase - neutral volts) or E1 (phase - phase volts) command is sent.

FREQUENCY SOURCE

FORMAT Q [0-3]

This command selects either the CH1 Volts or CH1 Amps or External as the frequency source.

Q0 Selects the Ch1 Volts
Q1 Selects the Ch1 Amps
Q2 Selects the external frequency input (0.1 Hz minimum)
Q3 Selects the external frequency input (5 Hz minimum)

This command resets the display and background averaging.

The Q2 command will take approx 25 seconds to make a reading if a low frequency (<5 Hz) is to be measured.

SELECT VOLTAGE RANGE

FORMAT RV [00-12]

Selects the voltage range.

RV00 Selects auto ranging

RV01 Selects 0.5 Volt Peak range (manual)

RV02 Selects 1.0 Volt Peak range (manual)

RV03 Selects 2.0 Volt Peak range (manual)

RV04 Selects 5.0 Volt Peak range (manual)

RV05 Selects 10 Volt Peak range (manual)

RV06 Selects 20 Volt Peak range (manual)

RV07 Selects 50 Volt Peak range (manual)

RV08 Selects 100 Volt Peak range (manual)

RV09 Selects 200 Volt Peak range (manual)

RV10 Selects 500 Volt Peak range (manual)

RV11 Selects 1000 Volt Peak range (manual)

RV12 Selects 2000 Volt Peak range (manual)

The commands RV01 - RV12 reset the display and background averaging.

The auto ranging command RV00 has no effect on averaging.

SELECT AMPS RANGE

FORMAT RA [00-12]

Selects the amps range of all three channels

RA00	Selects auto ranging
RA01	Selects 0.05 Amp Peak range (manual)
RA02	Selects 0.1 Amp Peak range (manual)
RA03	Selects 0.2 Amp Peak range (manual)
RA04	Selects 0.5 Amp Peak range (manual)
RA05	Selects 1.0 Amp Peak range (manual)
RA06	Selects 2.0 Amp Peak range (manual)
RA07	Selects 5.0 Amp Peak range (manual)
RA08	Selects 10 Amp Peak range (manual)
RA09	Selects 20 Amp Peak range (manual)
RA10	Selects 50 Amp Peak range (manual)
RA11	Selects 100 Amp Peak range (manual)
RA12	Selects 200 Amp Peak range (manual)

The commands RA01 - RA12 reset the display and background averaging.

The auto ranging command RA00 has no effect on averaging.

INTERNAL / EXTERNAL SHUNT SELECTION

FORMAT S [0-1]

This command selects the internal shunt or external voltage input for the current channel.

S0 The AMPS input is taken from the 30 Amp Shunt.
S1 The AMPS input is taken from the external input.

This command resets the display and background averaging.

TRIGGER

FORMAT T [1]

Triggers the instrument to take a reading after the B1 command has been sent. (Selected results mode).

T1 The selected results will be prepared for output after the next measurement cycle.

PARALLEL PORT CONTROL

FORMAT U [00-63]

Controls the lowest five bits on the parallel port.

U00 Resets bits 0-4
U03 Sets bits 0,1 Resets bits 2,3,4

The parallel port may be utilised with this command to switch external logic.

ANALOG OUTPUTS ONLY SELECTION

FORMAT W [0-1]

Converts the signal on each input channel to a 0-5 Volt analog output.

W0	Turns off the analog outputs
W1	Turns the analog outputs on

All other functions are suspended while the analog outputs are enabled.

This command will be ignored if the integrator is running.

Analog connector (25 way 'D' socket)

Pin 1	-	Amps Channel 1
Pin 3	-	Volts Channel 1
Pin 5	-	Amps Channel 2
Pin 7	-	Volts Channel 2
Pin 9	-	Amps Channel 3
Pin 11	-	Volts Channel 3

Pins 2,4,6,8,10,12 - Ground

Channels 2 and 3 will only be operative if the wiring is selected for multi - phase (P2 - P4).

The wiring and range commands (P and RV,RA) are still available with the analog outputs enabled.

DATA LOG

FORMAT X [0]
X [1] _x_x_x

This command allows entry to the data logging routines. A 'B1' command should be sent first to specify which results are to be calculated and stored. If the integrator is running this command will be ignored.

X0 Exits the data log mode and should be used before returning to normal operation.

X1 Enters data log mode. There are three fields

1. CAPTURE TIME 0-4

X1 0 x x 30 milli Seconds (*)
X1 1 x x 60 milli Seconds
X1 2 x x 300 milli Seconds
X1 3 x x 1 Second
X1 4 x x 5 Seconds

(*) 30 milli second capture time is not available with the three phase four wire configuration. If it is selected the instrument will default to the 60 milli second capture time.

ii. INTERNAL OR EXTERNAL TRIGGER

X1 x 0 x The PM3000 will start data logging without waiting for any further trigger.

X1 x 1 x The PM3000 will wait for either:
a) The external trigger input to be brought low.
b) An IEEE bus GET (Group Execute Trigger)

iii. DATA DUMP

This will allow the user to transfer the data captured during data log to the computer for further analysis. After the data log is complete a 'B3' command must be sent to read the samples.
The 8 bit data (000-255) will be returned for each channel (plus neutral if applicable) in the following formats:

SINGLE PHASE TWO WIRE	V1 A1	(6000 Samples/Channel)
SINGLE PHASE THREE WIRE	V1 A1 V2 A2 N	(3000 S/Ch)
THREE PHASE THREE WIRE	V1 A1 V2 A2	(3000 S/Ch)
THREE PHASE FOUR WIRE	V1 A1 V2 A2 V3 A3 N	(3000 S/Ch)

X1 x x 0	Data Dump off
X1 x x 1	Data Dump on

To use the data log mode with the data dump facility:

a. Set the list of results required with the B1 command.

b. Send the X1 x x 1 command.

c. Wait until data log is complete.

d. Read the results.

e. Send 'B3'.

f. Read the data (3000 or 6000 sets of samples).

g. Send 'X0' data log off.

FUNDAMENTAL (FUND) DISPLAY SELECTION

FORMAT Y [0-1]

Turns the fundamental lamp on or off to select the fundamental component of the displayed results.

Y0	Display reads total values (Fund LED off)
Y1	Display reads fundamental values (Fund led on)

This command will not work where the fundamental button would not have valid effect (e.g. fundamental amps peak is not valid).

EXAMPLES

PM3000 address 9

To read single phase VA ,WATTS and POWER FACTOR on CH1

Send MLA 9	address the PM3000 to listen.
Send 'P1DL2DR3F05Y0B0'	Set to single phase with W,VA,PF on the display, turn fundamental LED off, Read from the display buffer.
Wait 0.5 secs	
Send MTA 9	address the PM3000 to talk and read 40 character string.

The PM3000 will return '+121.52 W 196.76 VA PF = 0.617 ',1f

A simple basic program to strip this string to give values in variables WATT, VA, PF -
RESULT$ contains the 40 character string from the PM3000

```
10      WATT$ = LEFT$(RESULT$,7)
20      WATT = VAL(WATT$)
30      IF MID$(RESULT$,8,1) = 'k' THEN WATT = WATT *1000
40      IF MID$(RESULT$,8,1) = 'M' THEN WATT = WATT *1000000

50      VA$ = MID$(RESULT$,12,6)
60      VA = VAL(VA$)
70      IF MID$(RESULT$,18,1) = 'k' THEN VA = VA *1000
80      IF MID$(RESULT$,18,1) = 'M' THEN VA = VA *1000000

90      PF$ = MID$(RESULT$,31,5)
100     PF = VAL(PF$)
110     END
```

EXAMPLE

PM3000 address 9

To read VOLTS,AMPS,WATTS,FREQ and AMPS HARMONICS (1-15 odds only) for a 3 phase 3 wire configuration CH1,CH2 and SUM.

Send MLA 9	address the PM3000 to listen
Send 'P3'	Set WIRING to 3 phase 3 wire
Send 'B1 11 0 10011000000000000001001'	Results to be returned from the background averaging store. Return ch1,ch2 and Sum results (1+2+8=11). No fundamental components Select: WATTS VOLTS AMPS AMPS HARMONICS FREQUENCY
Send 'L15 1'	Harmonics 1,3,5,7,9,11,13,15 and thd

The display will now read HARMONIC ANALYSIS RUNNING .

The PM3000 will now analyse all the parameters requested.

Send 'T1'	Trigger

This will store the results immediately the next measurement cycle is complete.

Wait 3 seconds.

The results requested may now be read from the PM3000.
An empty string will be returned if the results are not ready.

If the a serial poll is sent to the PM3000 bit 0 of the status byte will show if data is ready to be read. Averaging information is also available from the status byte.

Bit 1 of the status byte shows when the results have been averaged to a preset limit. This can be used to ensure that the results are stable and full accuracy is maintained.

or

WAIT x Secs

and then send 'T1' Trigger

The results will be averaged over the delay period and the averaged results will be stored at the end of the following measurement cycle.

or

Send 'M1' Enable service request

A service request will be generated at the end of every measurement cycle. The status byte can then be read.

Bit 1 of the status byte will be set if the averaging has reached its maximum.

When bit 1 is set send 'T1'

The results will have been averaged to give the best stability and accuracy.

The number of averages could have been set with the 'Axx' command. With auto averaging the default is 16.

After the trigger 'T1' has been sent the results will be ready to be read following the next measurement cycle.

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For repair service under warranty, this instrument must be returned to a service centre designated by Voltech. Purchaser shall pre-pay shipment charges to service centre and Voltech will pay shipment charges to return the instrument to purchaser.

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